EPiC Series in Built Environment

Volume 3, 2022, Pages 533–541

ASC2022. 58th Annual Associated Schools of Construction International Conference

Hands-On Approach to Teaching Construction Materials and Methods: A Case Study

Herman E. Burge II, M.S.
University of Oklahoma
Norman, OK

Bryan Bloom, M.S.
University of Oklahoma
Norman, OK

Anthony Perrenoud, Ph.D.
Boise State University
Boise, ID

At the University of Oklahoma, the Construction Science Division provides a Hands-on Class in which Construction Management students get the opportunity to learn construction methods and materials while building with their hands. In 2018, the graduate and undergraduate level course constructed two multi-family (2,936 Square Feet) dwellings in Norman, Oklahoma during the Spring semester. The units were purchased from the Norman Housing Authority and now provide housing for low-income citizens within the University community. The goal of this paper is to record and present the Kinesthetic and Collaborative pedagogies used in this unique class. A brief literature review explores the previous research on Kinesthetic and Collaborative pedagogies. The case study includes discussion on how the project was planned, designed, funded, and executed. The case study also presents how the class was coordinated, how student and subcontractor labor was utilized, the challenges faced during this process and future recommendations for similar classes. This case study adds to the body of knowledge by providing a detailed description of a Construction Education course that adds value to the local community by designing and building low-income housing.

Key Words: Kinesthetic, Collaborative, Pedagogy, Construction Education, Community Outreach

Introduction

In the 1963 James Bond film *From Russia with Love*, the fictitious character Rosa Klebb said, "training is useful, but there is no substitute for experience." With the increasing demands for "industry ready" professionals in the Construction industry, it is indicative that higher learning institutions keep pace and develop students to successfully transition and lead productive careers. The objective of this research is to document the pedagogies used in the Construction Fundamentals Lab at the University of Oklahoma in the Construction Science (CNS) program. This allowed for students to combine their technical and practical skills on an active construction site, in which two multi-family

duplexes (named the Hughbert Street Project) were newly constructed. This class experience provided two great outcomes with the students, first learning by doing, on a real construction site, and second, developing meaningful working relationships with professors, fellow students, and industry professionals. This paper presents the case study of this unique hands-on experience and the literature that validates this method of instruction.

Literature Review

The evolution of the construction industry must start with the development of the leaders and the workers that will carry the industry forward. Construction education is critical for the strength of the industry. Most programs offer a variety of courses in construction technology and management philosophy along with courses from other disciplines to strengthen students' knowledge and skills from other perspectives. Furthermore, construction management education focuses on the entire life cycle of a project. This includes initial planning, design, site construction, occupancy and maintenance, condition assessment, retrofit, and renovation or removal (Lee et al. 2013). at the University of Oklahoma in the Construction Science (CNS) program, the undergraduate Construction Science program's mission is to develop, organize, and manage a successful team of the various design and building disciplines requires technical, communication, and teamwork skills (University of Oklahoma, 2019).

According to Mobley and Fisher, learning through movement should be fully incorporated into college pedagogy (Mobley & Fisher, 2014). Equipping students with practical knowledge prepares those students to enter the construction industry and contribute immediately. "Kinesthetic," as used in the study, describes muscular movement in response to visual, auditory, and tactile stimulation, aka hands-on learning (Grant, 1985). Marie Grant states "the Kinesthetic approach to teaching relies on the students' active, physical participation… allowing them to discover their education and individual capabilities." Integrating kinesthetic methods is one solution with the benefit of immediate and deeper learning for students.

Dowling (2012) writes, "the challenge for instructors to create materials that engage students physically, intellectually and emotionally can provide opportunities for individual connections and learning that is retained over time with long-term memory". Learning from hands-on experiences invites experimentation and exploration that engages the hand, body, and brain differently. This shift in pedagogy from traditional lectures provides students with a completely different learning experience. Hands-on learning allows students to engage and invest in their education in new ways and students make the transition from passive learners to active learners (Scott & Ghosh, 2016). This method requires a great deal of planning and additional resources outside of the normal classroom.

In addition, students are often taught to focus on learning their discipline, but they are unaware of how to collaborate with others (O'Brien, et al. 2003). Traditional teaching and learning pedagogies, often at higher learning institutions, are that of a lecturer broadcasting one-way information to the audience. When information is transmitted this way, students are limited in their exposure. Construction Management programs should foster collaborative learning experiences. Gunderson & Adams writes, "in-group cooperative learning environments, students work in a structured group to perform a well-defined task or to understand a particular concept with the purpose of every individual within the group developing his or her academic and social skills to the maximum" (Gunderson and Adams, 2006, p. 2). For the collaborative pedagogical approach to be successful, education professionals must "provide good guidance and an induction session for students immediately prior to the

commencement of the projects" (Scott and Ghosh, 2016). The following case study presents a teaching method that provided a hands-on learning experience for construction students.

Case Study

Planning and Stakeholders

The instructor of the Hands-on lab, Professor Bryan Bloom at the Construction Science Division at the University of Oklahoma, also teaches the Materials and Methods II class. Prior to 2018 the hands-on lab only constructed portions of a building, i.e., concrete foundation, CMU wall, portions of MEP systems, and components of the ceiling. The instructor explained that the larger project in the Hands-on lab stemmed from the thought of "why not actually do something, build something that we are going to keep or that is for the community." The instructor set off with the challenge to provide both a learning experience for his students and something for the community. The idea was to provide low-income housing to the city of Norman that was constructed by CNS students.

The first challenge was funding. The instructor communicated with four key stakeholders to get the ball rolling. The first stakeholder, and one of the most important, was an external partner of the CNS program at the University of Oklahoma who would be willing to help with initial funding. The land seemed to be reasonably priced, and the investor thought it was a great idea. The investor provided the equity/cash to purchase an identified piece of property in Norman, OK. The second stakeholder was the Dean of the College of Architecture which houses the CNS division. The Dean, a licensed Architect, and his firm, agreed to provide the architectural plans pro bono.

The Third stakeholder was the Norman Housing Authority (NHA) and the Norman Affordable Housing Coalition Corporation (NAHCC). With a "cold" call to the NHA, the instructor presented the plan to both the NHA and NAHCC to have the CNS students construct affordable housing in the City of Norman. The plan was to design and construct homes in a way that would tailor to a specific tenant that has disabilities or other ailments. In addition, use systems and materials that do not require a lot of maintenance. The NHA saw the vision and was excited that they could also have some input in the design of the homes. The typical NHA model for acquiring homes is to acquire existing housing which often does not allow for occupants with disabilities. With the help of the NHA, the architect was able to develop a design that fulfilled the needs of housing for NHA. Further description of the design is provided below. From the beginning, the NHA seemed to be extremely excited to partner with the University. Upon completion of the housing, the NHA agreed to purchase the buildings for low-income housing.

The final stakeholder was a local bank that would provide a construction loan. The architectural drawings were sent to the bank to show the intended structures. An estimate also had to be provided, which was challenging because the instructor had to estimate how much labor the students would provide. The instructor anticipated that what the students would not be able to complete would need to be completed by subcontractors. Upon hearing the plan from the instructor, the bank approved it and financed the project during construction. The deal was structured so that Mr. Hacker, would own the land and the buildings during construction and it was provided as a non-recourse loan. Mr. Hacker was the owner and developer and at the end of construction, entered into a sales agreement with the Norman Housing Authority, who bought it for the negotiated price.

The project site is located at 115 W Hughbert St, Norman Oklahoma. As it was located on Hughbert St, it began to be referred to as the 'Hughbert project'. The instructor contacted the owner and negotiated the price for the Hughbert Street land. A contract for the project was agreed upon in November 2017, the purchase of the lot was closed in December of 2017, and construction was set to be started during the Spring semester of 2018. The turnaround time for planning from beginning to end was extremely fast. A deal of this nature can sometimes take months or years to close.

Design and Permitting

With a quick turnaround in mind, the design immediately began designing the project once the agreement was entered. With the help of the NHA, the design team was able to meet the low housing income needs with two duplexes on the lot. Each duplex provided two, 1-bedroom ADA accessibility homes, for a total of four low-income homes. Fortunately, the land was zoned multi-family residential (R-2) which allowed for the design of two duplexes on the lots. The design of the duplex can be seen in Figure 1. The total square footage for the four units is 2,936 Square Feet. The most glaring design challenge was the location of the lot directly next to an active railway, to the west. A lot of attention was given to the orientation of the duplexes to create a sound barrier for the west wall on both units. The solution to alleviate some of the sound from the train was to design the entire west wall to be a big shingle wall with no windows. The other side of the shingle wall called for a double stud wall, with a one-inch air gap, and insulated both walls for noise and for thermal resistance. The design team finalized the concept and plans and submitted everything to the City of Norman within two weeks. The residential building permits were applied for immediately after the land was purchased and approved in two weeks. The instructor stated, "Honestly, another partner, on this project, was the City of Norman. They saw what we were trying to accomplish and helped move the process along a little quicker."

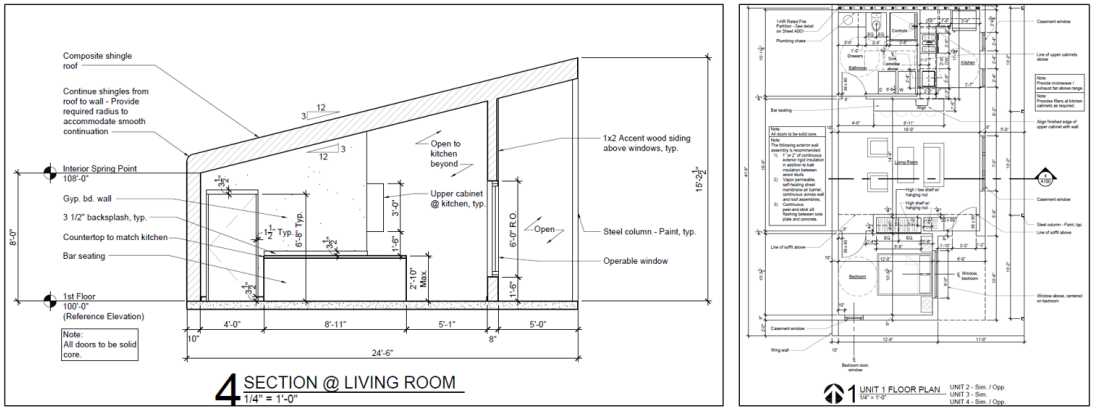

Figure 1. Cross Section and Floor Plan for the Four Units

Class Coordination and Construction

The instructor organized the Hughbert project around two CNS classes, the Materials and Methods II (MMII) class and the Fundamentals Lab class. MMII meets two days a week (Tuesday and Thursday) for 75 minutes in a classroom and the Fundamentals Lab class meets once a week (Friday) for four hours. The instructor used the MMII class times to instruct students on the methods and materials that they would use on the project and would use the Fundamentals Lab time to work exclusively at the

construction job site. The classroom lectures, generally, went hand-in-hand with the activities or tasks that were to be completed on the Hughbert project. Having the job site close to campus was a major benefit for students to be able to travel between the site and campus. Most students, in the Materials and Methods II (MMII) and Fundamentals Lab, were experiencing hands-on construction processes for the first time. The objective was not to train students to be carpenters but to provide an experience so they understand what they would be asking of their skilled trades workers.

A 16-week semester allowed for 16 days in which the CNS students would be able to build the houses. The instructor's desire was to allow the students to see as many aspects of the project as possible. The instructor warned the students on the first day of class that the schedule would need to be flexible in the class syllabus. The hope was that the students would be able to experience the construction processes up to the finishes of the interior millwork. The actual schedule ended up falling a couple of weeks behind in comparison to the expected schedule. Ultimately the students would only see construction up until drywall during the spring semester. There were at least two weeks that the students could not work due to spring break, weather delays, and inspections.

The instructor began some of the construction before the spring semester in order to get out of the ground. It was important to get out of the ground as construction can be delayed in the early stages, especially in January when the weather, in Oklahoma, can be very unpredictable. The design of the duplexes allowed for foundation work to occur quickly and without changes. The footings and stem wall were completed prior to the commencement of the Spring semester. The students would still be able to see the groundwork (electrical and plumbing) and concrete with pouring the slab.

Figure 2. Students Framing and Raising Wall

Each lecture session was, generally, structured so the building process introduced in MMII corresponded with the work to be completed in the lab sessions on Friday. During the Tuesday lecture, the materials and methods would be introduced for a new portion of construction. For example, window installation would be introduced on Tuesday in which the instructor would review the window specifications with the class and explain the methods used to install the windows. In Thursday's class, the students would be given an assignment meant to explore the upcoming systems, products, or materials. For windows, the assignment would include confirming measurements of the windows and rough opening, to verify the opening was flashed properly to combat water infiltration, and be sure they understand the techniques for installation. This allowed students to become familiar with that specific process before they would get hands-on experience. The instructor designed each Friday lab with two learning objectives:

1. learn how different systems and products were installed, and
2. engage and work with fellow students and industry professionals

Friday afternoons were designated as lab days. The goal was for students to recall what they learned on Tuesday and Thursday and apply it on Friday, by installing a product or material. During the lab days, students were paired and given directions on the tasks that were to be completed that day. During the lab days, students framed the exterior walls (see Figure 2), installed the exterior sheathing, windows, doors, insulation, and drywall.

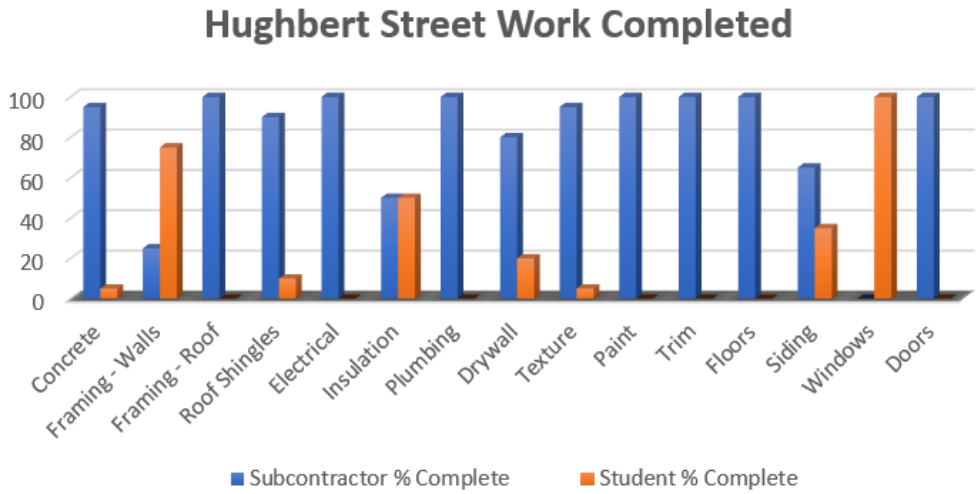

Figure 3. Percentage of work completed on the Hughbert Street project.

To experience multiple portions of the construction process, subcontractors were needed in addition to the student work to stay on schedule. During planning, the instructor identified subcontractors to help on the project as he knew that the students would not be able to complete all work across the project during the 16-week schedule. In addition, subcontracted work that had to be done by licensed trades such as HVAC, electric, and plumbing was included in the initial budget. The instructor selected the subcontractors based on personal relationships developed through his local home building company. The students were able to work on many portions of the project, ultimately subcontractors performed the majority of the work as can be seen in Figure 3. On the project site, an issue for surrounding neighbors was parking. To avoid overcrowding, the instructor instructed the subcontractors to complete their work by Thursday afternoon so the students would be able to work on Fridays. By the end of the semester the students completed the drywall. After the semester, the instructor finished the construction of the duplexes with the subcontractors.

Course Reception and Feedback

Upon completion of the courses, students performed course evaluations through the University. The two courses were found to be two of the most effective courses within the Construction Science department. Table 1 presents four of the questions that are provided in the student evaluation process. Students are asked to evaluate each question on a 5-Point Likert Scale, with 1- being Strongly Disagree and 5- Strongly Agree. Compared to the Mean within the Construction Science Department,

the students found the class to be highly effective. The Mean for both classes were higher than the Department's Mean and the Standard Deviation was much smaller for both classes, which demonstrates the consensus of the students with the courses. Additionally, there were many student comments similar to the following with the case study.

"This was my favorite course this semester. Learning on the job and seeing construction in action was much more effective than any class I have sat in. The Professor did an excellent job at answering questions, fixing problems, and guiding the students along the way. Learning the steps and methods of construction at an actual site was very beneficial."

Student Comment

"A few of the things that I liked about the course was getting hands on experience with an actual project, getting an understanding of certain building materials and actually how to apply them. The Professor taught us by showing us how to do the work and then challenged us to do it ourselves.

Student Comment

Table 1
Student Perception and Impact of the Two Combined CM Courses

	Fundamental Lab Course			Material and Methods Course			Department Courses	
Questions	N	Mean	StDev	N	Mean	StDev	Mean	StDev
In this course I gained a basic understanding of the subject (e.g., factual knowledge, methods, principles, generalizations, theories).	34	4.882	0.327	46	4.826	0.383	4.388	0.884
In this course I learned to apply course material to improve problem solving.	34	4.941	0.238	46	4.761	0.431	4.272	1.016
In this course I learned to critically evaluate ideas.	34	4.794	0.41	46	4.652	0.526	4.144	1.076
Overall, I rate this course as excellent.	34	4.941	0.239	46	4.804	0.401	4.134	1.193

Challenges and Recommendations

Like most construction projects, the major challenges dealt with time and budget. With regards to time, the major challenge was ensuring that the project and materials were ready for the students on Friday. It was difficult to manage time with regards to ensuring that the students had the necessary guidance prior to coming to work on the job. Once the lab started there would typically only be enough room or tools in which smaller groups could work on the project at a certain time. To mitigate overcrowding the students were broken up into groups and would work in sequential order. The instructor was challenged to setting everything up for the first group and then prepare the next group to follow. There was a loss of production between each group during the tight 4-hour time frame. Given the circumstances, the students were not coming back the next day to perform a familiar task, they were coming back seven days later, and facing a completely new task. For example, one week the students would start installing sheathing, and the week after they would be installing windows, and so there was always a new problem or issue to solve with the logistics of the lab. It was difficult

to get good momentum during the labs between the different groups of students. In addition, there was a limitation on the number of tools available and students had to share tools. Since the lab only had sixteen scheduled meetings, the design of the structure was simple enough for inexperienced students to build but in retrospect, the design could have been simplified even more. The instructor would recommend a smaller scope of design for future projects.

The balance of the project was funded through a construction loan. Developing and maintaining the budget was the other major challenge. As the students would not be paid for their labor the instructor had to develop the initial budget with estimating how much work would be accomplished by the students and the subcontractors. The budget was a "moving target", because of the unpredictability of the remaining balance to complete the project and to try to meet the NHA buying price. Initially, the instructor provided the bank with a worst-case scenario in which he would have to hire subcontractors to do all the work. With the students participating in the construction of the duplexes, the instructor was able to offset labor costs allowing them to save money. Periodically during the project, the instructor would gather all the construction costs and send it to the bank. In hindsight, the instructor believes being more exact on the estimate would have set the project up better. Since the pre-construction phase had to occur so quickly, he was only able to provide a conceptual estimate, which meant every detail of the estimate was not fully verified. The instructor's experience as a custom home builder gave him the assurance the estimate was within range of the actual cost. However, the instructor would recommend more time during pre-construction in which a more accurate estimate could be developed. Also, securing a buyer and establishing a final price sooner would have been ideal. Knowing the expectations, the NHA may have had, and allowing for more time to plan the project. As it became clearer that the NHA would be purchasing the duplexes the instructor was able to accommodate them more. For example, installing a specific product or installing a ramp.

For this class methodology to be sustainable on a year-to-year basis, funding and the right end-user must be secured. More time will be needed and, possibly, a full year to complete a project of this magnitude. The instructor believes it is critical to involve other disciplines within the college of architecture, including architecture, interior design, and landscape architecture students. This could develop an environment where the design and construction students could engage and establish a collaborative approach during their education. The instructor also recommends that this class should only be for students who are dedicated to something of that magnitude. Having the class be an upper elective or graduate course would ensure that the students that are enrolled in the class are dedicated to the class objectives. When students didn't arrive on time or took longer than planned, that ended up costing more money.

Conclusion

In 2018, the construction science department provided their students with a hands-on experience in which they participated in the construction of low-income housing. The project was spread across two classes in which two duplexes were constructed during a semester. The instructor incorporated Kinesthetic and Collaborative pedagogical approaches into the course and lab. In the end, the instructor received high levels of satisfaction from the students, faculty, and community leaders. The course evaluations demonstrated that the students were very enthusiastic with the approach of instruction. This paper contributes to the body of knowledge by providing a detailed case study of a hands-on course that also served the local community. Including the funding, planning, design, and coordination required. The experience and knowledge gained through this experience would serve

valuable for other construction science programs that are looking for a unique hands-on approach to a construction education.

References

Dowling, C. (2012). The Hand: Kinesthetic Creation and the Contemporary Classroom. *The International Journal of Learning*, *18*(8), 51–66.

Grant, S.M. (1985). The Kinesthetic Approach to Teaching: Building a Foundation for Learning. *Journal of Learning Disabilities*, *18*(8), 455–462.

Gunderson, D. E., & Moore, J. D. (2008). Group learning pedagogy and group selection. *International Journal of Construction Education and Research*, *4*(1), 34-45.

Lee, S., Esmaeilzadeh, A., & Lee, D. (2013). Graduate Construction Management Programs in the U.S.: Lessons Learned from Leading Institutions. *KSCE Journal of Civil Engineering*, *17*(7), 1664–1671.

Mobley, K., & Fisher, S. (2014). Ditching the Desks: Kinesthetic Learning in College Classrooms. *The Social Studies*, *105*, 301–309.

O'Brien, W., Soibelman, L., & Elvin, G. (2003). Collaborative design processes: an active-and reflective-learning course in multidisciplinary collaboration. *Journal of Construction Education*, *8*(2), 78-93.

Scott, L., & Ghosh, S. (2016). Collaborative approach in construction education: towards a more constructivist experience. In *Associated Schools of Construction, 52nd Annual Conference Proceedings, New York, NY* (pp. 1-7).

University of Oklahoma. (2019, September). About the Division of Construction Science. Retrieved November 2, 2021, from https://architecture.ou.edu/wp-content/uploads/2019/10/About-the-Division-of-Construction-Science.pdf.